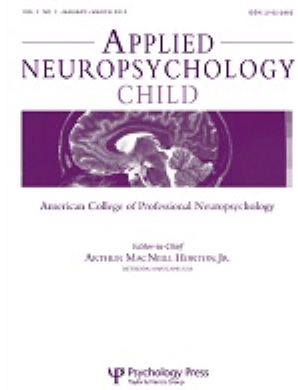

Visual memory profile in children with high functioning autism

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Visual memory profile in children with high-functioning autism

Abstract

Visual memory in children with high-functioning autism (HFA) is an area of debate. According to the few studies that have examined visual memory in children with autism, the memory profile appears to vary according to the memory process and type of stimuli, and contrasting results may be found. This study aims to analyse the visual memory profile of children with HFA.

Fifteen children with HFA (mean age 9;6) and 15 typically developing children (TD; mean age 9;2) matched by chronological age and Leiter-R Brief IQ score took part in the study. Associative and recognition memory as well as visuospatial working memory were assessed.

Impairments in face recognition and forward memory were found, whereas associative memory and shape recognition were preserved. The memory profile in children with Autism Spectrum Disorder (ASD) showed relatively stronger abilities in associative memory than in the other visual memory domains.

The results support the hypothesis that the level of stimulus processing may influence memory performance by having a large impact on tasks and stimuli that require access to a semantic or global level of processing. In contrast to the TD population, children with ASD may have difficulty extracting underlying regularities from experiences and generalizing that information.

Keywords

Visual memory; Face recognition; High-Functioning Autism; Children; Leiter-R.

Highlights

Children with HFA show preserved ability in associative memory and shape recognition.

Face recognition appears to be a specific deficit in children with HFA.

Associative memory appeared to be the strongest ability in the memory profile of children with ASD and TD children.

Running head: Visual memory in autism

Visual memory profile in children with high-functioning autism

The present study aims to investigate the visual memory profile in children with high-functioning autism (HFA) by minimizing the use of verbal language. Associative memory, shape and face recognition, and visuospatial working memory are considered. The nature of memory function in autism spectrum disorder (ASD) has been studied for decades (Boucher, Mayes, & Bigham, 2012). Bowler, Gaigg, and Lind (2011) suggested that even if ASD is not caused by difficulties in memory, as was argued by early researchers who formulated the hypothesis of an amnesic-like disorder in autism (Boucher & Warrington, 1976; Mottron, Morasse, & Belleville, 2001), the pattern of memory seen in individuals with autism can help to better understand their cognitive functioning and unique inner experience of the world (Boucher & Bowler, 2008).

In particular, the weak central coherence (WCC) account (Frith, 1989; 2012) has often been used to explain the differences in processing that are found in individuals with ASD. According to the WCC theory, children with ASD may be characterized by reduced global processing and an enhanced tendency to focus on specific details of stimuli (Frith, 1989). This processing bias was evident in early studies on verbal memory, showing relatively little benefit from meaning, and in visuo-spatial memory tasks, where people with ASD remember each exemplar rather than extracting prototypes in order to generalize (Happé & Frith, 2006). Similarly, Quian and Lipkin (2011) suggested that individuals with ASD might be more prone to precisely store experiences and to accumulate a large number of examples instead of generalizing. This strategy, named lookup table learning (LUT), is considered to be the opposite of the interpolation learning (INT) strategy, which is representative of the typically developing (TD) population learning style that focuses on extracting underlying regularities from experiences in order to generalize and categorize.

Understanding the mechanism behind ASD memory difficulties could be the basis for building strategies to support the different impaired domains (Semino, Ring, Bowler, & Gaigg, 2018). Since several aspects of visuospatial processing have been found to be preserved in children with ASD, interventions based on vision have been developed to support these children in different areas (Schopler, Mesibov, & Hearsey, 1995; Ganz, 2007). However, it is unclear whether this strength translates into long-term learning, for which memory is a fundamental process. For instance, there are some inconsistencies in performance due to different factors, such as the use of various targets and demands, the degree of dependence on verbal ability, and the potential effects of age and intelligence (Chien, Gau, Shang, Chiu, Tsai, & Wu, 2015).

Regarding the effect of age, the literature shows that impairments in visual memory may vary with age, becoming more pronounced from adolescence to adulthood (O'Hearn, Tanaka, Lynn, Fedor, Minshew, & Luna, 2014). Chien et al. (2015) investigated the effect of age on memory for meaningless shapes and found an improvement in performance from childhood to adolescence in both the TD population and individuals with ASD. However, the magnitude of the improvement was less pronounced for individuals with ASD. A different developmental pace may explain the discrepancies found in the level of impairment observed from childhood to adulthood.

Other sources of variability that may influence children's performance should be considered when studying visual memory in autism. Considering the processes involved, associative memory must be distinguished from other types of memorization — namely, recognition. In both cases, tasks can be designed to assess immediate recall versus delayed recall and can be structured as free recall or cued recall. Moreover, the literature emphasizes the social nature of memory deficits (Brezis, Galili, Wong, & Piggot, 2014). In this field, studies comparing the memory ability for faces in persons with ASD and in non-autistic groups highlight the specific nature of this deficit (Williams, Goldstein, & Minshew, 2005a). Finally, visuospatial working memory (VSWM), responsible for both the maintenance and processing of visual (e.g., colour, shape, texture) and spatial (e.g., position of an object in space) information, involves processes that are different from those used for associating or recognizing stimuli that have already been presented to the subject.

Associative memory in children with Autism Spectrum Disorders

Research on associative memory focuses on the ability to learn and remember the relationship between unrelated stimuli (Suzuki, 2005). Most research on associative memory in autism has involved adult participants and has found that cued recall and paired associative learning are preserved in individuals with moderately low-functioning autism as well as in high-functioning autism (Boucher, Mayes, & Bigham, 2012; but Funabiki & Shiwa, 2018). Even the few studies on associative memory in children, who were evaluated using cued recall and paired-associated learning tasks using both verbal and visual methods, describe this type of ability as a relative strength for individuals with autism (Boucher & Warrington, 1976). In particular, children with HFA appear to have preserved performance in tasks that require the association of symbols and sounds, in memory for locations (Williams, Goldstein, & Minshew, 2006), and in the musical domain, namely, in pitch memory and labelling (Heaton, 2003). In the opinion of several authors, rote and associative memory skills are not affected in autism (Bennetto, Pennington, & Rogers, 1996), whereas materials with increased complexity and organizational structure negatively affect memory and learning in these individuals (Williams et al., 2005a).

Recognition memory in children with Autism Spectrum Disorders

As stated by Holcomb and Dean (2011), recognition memory is considered to be the type of memory that allows for the identification of verbal or visual stimuli that were previously heard or seen. In this domain, children with HFA show preserved performance compared to TD children using different stimuli: common and unfamiliar objects (Hill & Russell, 2002), for example, buildings (Boucher & Lewis, 1992); common and meaningless shapes (Bigham, Boucher, Mayes & Anns, 2010; Boucher, Bigham, Mayes, & Muskett, 2008); pictures, landscapes and colours (Boucher et al., 2012); and stimuli in the auditory-verbal domain, such as word lists and stories (Salmond, Ashburner, Connelly, Friston, Gadian, & Vargha-Khadem, 2005). Some research on adults with autism even found superior recognition memory in these individuals for non-social stimuli and non-agency objects, such as leaves and buildings (Blair, Frith, Smith, Abell, & Cipolotti, 2002).

A number of studies suggest that individuals with ASD show a domain-specific impairment for faces (Snow et al., 2011; Williams et al., 2005a). This type of deficit is considered particularly important because of its association with the social disability evidenced in autism. Although the interpretation of research on face recognition in children, adolescents, and adults with autism is challenging because both the sample populations and methods significantly vary among studies, there is nevertheless strong evidence indicating processing peculiarities, even when task performance is not impaired (Klin et al., 1999). For example, as recently shown, face processing involves two distinct processes, i.e., face perception and face memorization; face recognition impairments found in individuals with ASD are more pronounced than face perception problems (Dwyer, Xu, & Tanaka, 2018). A study by Klin et al. (1999) comparing three groups of seven-year-old children with autism, pervasive developmental disorders not otherwise specified (PDD-NOS), or disorders other than PDD who were matched for chronological age and non-verbal mental age confirmed the hypothesis that young children with autism also show a specific face recognition deficit. Comparing the children's performance in a face recognition task, a gestalt closure task, and a spatial memory task, the authors found that children with autism performed worse than children in the other two groups in terms of the face recognition task; moreover, this face recognition deficit was independent of both the verbal and non-verbal mental age of the children. The groups did not differ in spatial memory, whereas a significant difference in the gestalt closure task, which was present when the groups were matched by non-verbal mental age, disappeared in a subsample matched for verbal mental age. The authors conclude that face recognition ability in children with autism is much less strongly correlated with the overall level of cognitive functioning than the other measured skills, thus representing a relatively unique deficit. Snow et al. (2011), using eye tracking, confirmed that adolescents with HFA were less accurate in recognizing previously seen faces than TD adolescents. Moreover, adolescents with HFA made fewer eye movements and shorter and fewer fixations outside the primary facial parts (eyes, mouth, and nose) than TD adolescents.

Visuospatial working memory in children with Autism Spectrum Disorders

Working memory (WM) refers to a system involved in maintaining and processing information simultaneously (e.g., Engle, Cantor, & Carullo, 1992). It has received specific attention in investigations of autism, and the tasks employed have been used to study both verbal and spatial skills (Williams et al., 2006). In particular, VSWM can be defined as the capacity to remember and update the spatial location of objects or people during motion or following momentary occlusion. Typically, the literature considers spatial span tasks, such as the Corsi block-tapping test (see, e.g., Macizo, Soriano, & Paredes, 2016) or the Finger Windows task (Williams, Goldstein, Carpenter, & Minshew, 2005b), as VSWM measurements. Spatial memory, more than visual working memory, was found to be compromised in populations with ASD (see, e.g., Funabiki & Shiwa, 2018; Williams et al., 2005a). As indicated by Jiang, Capistrano, and Palm (2014), research has provided inconclusive evidence on whether children with autism are impaired in this capacity. In the same year, Kercood, Grskovic, Banda, and Begeske (2014) conducted a literature review that aimed to evaluate existing WM research on individuals with ASD. In particular, 20 of the 24 examined studies assessed children or teenage populations. The results suggest that persons with high-functioning autism score lower on measures of working memory than typical controls. Individuals with ASD demonstrate decreased performance in tasks that require cognitive flexibility and a large working memory load and spatial working memory load, especially with increased task complexity. Similar conclusions were deduced in a recent meta-analysis of WM impairments in individuals with ASD (Wang et al., 2017). Analysing the results of twenty-eight studies, the authors concluded that individuals with ASD showed WM impairments across age and in all kinds of WM tasks, especially in spatial tasks, compared to typical controls. However, other authors (Ellis Weismer, Davidson, Gangopadhyay, Sindberg, Roebuck, & Kaushanskaya, 2017) outlined that task complexity and sample characteristics were likely to contribute to the discrepant findings on WM abilities in individuals with ASD.

Recent research by Mammarella, Giofré, Caviola, Cornoldi, and Hamilton (2014), in which eight males with HFA without intellectual disability and eight males with typical development were compared, found overall similar performance between the groups in the VSWM tasks. The only difference between the two groups was that despite a similar overall performance in the VSWM task, children with HFA did not have an advantage with the high semantic stimuli. In contrast, Jiang et al. (2014) found a significant difference between children with high-functioning autism and age, sex and IQ-matched typically developing children in a match-to-sample spatial working memory task. The apparent discrepancy in the results can be explained by the different processes required by the two tasks. In fact, while Mammarella and colleagues asked participants to recognize a global figure, Jiang and colleagues asked children to recognize the position of a single dot in a global configuration. It has also been suggested that difficulty in managing spatial working memory tasks might be due to different requests in terms of executive processes employed in memory performance, rather than memory processes, per se (Wang et al., 2017; see also Hamilton, Mammarella, & Giofré, 2018).

Intellectual functioning and visual memory

Macizo et al. (2016) consider IQ to be an additional confounding factor that is difficult to control for by simply matching the groups by verbal or non-verbal IQ. Several abilities, such as planning, are thought to be related to IQ differences (see, e.g., Bennetto et al., 1996), whereas other studies, such as WM research, have not yet determined whether the differences in performance are moderated by intellectual functioning. Moreover, Salmanian, Tehrani-Doost, Ghanbari-Motlagh, & Shahrivar (2012) found that visual memory differences between TD youths with those with ASD turned out to be nonsignificant after controlling for IQ. As observed by Chien et al. (2015), intelligence may have potential effects on visual memory, especially using a visual memory task that requires semantic memory instead of meaningless shapes that are difficult to label and are more independent from cognitive functions other than visual memory.

Present study

In summary, the memory profile of children with HFA appears to vary according to the memory process and type of stimuli. To date, few studies have examined visual memory in children with autism, and these studies are generally heterogeneous both in terms of the memory processes examined and the types of tasks employed. People with high-functioning autism appear to have preserved associative and recognition memory for objects and shapes and a deficit in face memory, while performance in VSWM is more controversial and can vary depending on the processes examined in the task and the complexity involved, e.g., in terms of the level of semantic organization of the stimuli (Mammarella et al., 2014) and the requested executive attentional control resources (Hamilton et al., 2018). In the abovementioned literature, few studies have examined the emergence of a broad range of visual memory abilities at the same time, particularly in childhood, thus making it difficult to highlight the relatively strong areas of the inner memory profile of individuals with ASD. Moreover, even research that uses visual stimuli also employs verbal language during the administration of the tests.

The present study aims to contribute to filling this gap by systematically investigating the visual memory profile of children with HFA compared to that of matched TD children using procedures and tasks that minimize the use of verbal language. Different aspects of visual memory are assessed, such as associative and recognition memory for shapes and faces, and VSWM for sequences of positions in the case of semantic stimuli (meaningful shapes) and meaningless stimuli are investigated. Moreover, considering the controversial role of IQ in differentiating the visual memory profiles of individuals with ASD and TD individuals (Chien et al., 2015; Salmanian et al., 2012), we investigated visual memory in children with normal non-verbal intellectual abilities. Since memory has an impact on learning, assessing different domains could be useful to help children create strategies that rely on their preserved abilities and to improve impaired abilities. Based on previous studies, we hypothesize that the two groups show a similar performance in associative memory and in recognition memory for shapes and differ in recognition memory for faces and in spatial working memory. Moreover, we expect to find an uneven visual memory profile in individuals with ASD, with a strength in associative memory and an ASD-specific deficit in recognition memory for faces and in spatial working memory, namely for semantic stimuli.

Method

Participants

Fifteen children with ASD (13 boys), with a mean age of 9;6 years (ranging from 7;6 to 12;4 years), and 15 TD children (12 boys and 3 girls), with a mean age of 9;2 years (ranging from 7;4 to 10;11 years), participated in the study. Children with ASD were recruited from four specialized centres located in north-western Italy. Clinical diagnoses were formulated in public health centres through a standardized method according to the ICD-10 criteria, which comprises the Autism Diagnostic Observation Schedule (ADOS; Lord, Rutter, DiLavore, & Risi, 2002; Gotham, Risi, Pickles, & Lord, 2007), the Autism Diagnostic Interview-Revised (ADI-R; Rutter, Le Couteur, & Lord, 2003), the Vineland Adaptive Behavior Scales (VABS, Sparrow, Balla, Cicchetti, 1984), the Autism Behavior Checklist (ABC; Krug, Arick, & Almond, 2008) and the Childhood Autism Rating Scale, Second Edition (CARS-II; Schopler et al., 2010). Participants with ASD did not show intellectual disabilities ($Mean_{IQ}$ = 91.73, S.D. = 11.23, range 76-111). Typically developing children were recruited from three different primary schools located in a major town in the north-western region of Italy. No children in the TD group had a history of neurological impairments or developmental disabilities. The ASD and TD groups did not significantly differ in terms of chronological age or Leiter-R Brief IQ (Roid & Miller, 1997; Table 1).

Procedure

Children with ASD were assessed in the clinic centres they attended. TD children were assessed in their schools. The assessment was conducted in a quiet room in two different sessions, which were one hour each. All the tests were administered by the same experimenter. Written informed consent was given by the parents during a preliminary meeting with the researcher. Before the test, the children were told that they would complete some tasks by playing various types of games. The study was conducted by conforming to the ethical standards established by the Italian National Psychology Association for Research.

Measures

Cognitive level was evaluated with the Leiter-R Brief IQ (Roid & Miller, 1997) obtained with the Figure Ground, the Form Completion, the Sequential Order, and the Repeated Patterns subtests. Memory was assessed using subtests from the Leiter-R scale (Roid & Miller, 1997) that were not used in the IQ estimation and from the Italian version of the TOMAL, i.e., Test of Memory and Learning (i.e., TeMA - test di memoria e apprendimento, Reynolds & Bigler, 2003) , as well as the Corsi block-tapping test (Corsi, 1972). All tests were chosen to minimize the need to use verbal language. The scaled scores were used as variables for each task.

Associative memory was assessed with the associated pairs and delayed pairs subtests (Leiter-R, Roid & Miller, 1997). In the associated pairs task, children were shown tables with an increasing number of pairs of pictures, and they were asked to memorize them. After each table, the examiner showed one picture from each pair and asked the children to complete them with the missing pictures. After 30 minutes, the children were assessed with the delayed pairs task. In this task, the children were shown the same table with one picture for each pair and were given cards to complete them. Cronbach's alpha was .69 for the associative pairs task and .68 for the delayed pairs task (Roid & Miller, 1997).

Recognition memory was assessed using two tests requiring the recognition of shapes, i.e., the immediate recognition and delayed recognition subtests (Leiter-R, Roid & Miller, 1997), and a test for face recognition, i.e., the facial memory subtest (Reynolds & Bigler, 2003). During the immediate recognition task, the examiner asked the children to memorize a complex picture. The children were then shown the same picture without certain details, and they had to recognize the differences between the different stimuli cards. After 30 minutes, the children were shown the pictures with the missing details and were again asked to recognize the differences between the different cards. Both the immediate recognition and delayed recognition tasks should be administered to children younger than 11 years of age. The scores of two children who were over 11 years of age were excluded from the statistical analysis. Cronbach's alpha was .84 for the immediate recognition task and .78 for the delayed recognition task (Roid & Miller, 1997).

The facial memory subtest from the Italian version of TOMAL (Reynolds & Bigler, 2003) was used to assess face memory. The children were shown an increasing number of black and white pictures of faces and were asked to recognize these faces hidden within a table containing a growing number of distracter faces. Cronbach's alpha was .82 (Reynolds & Bigler, 2003).

The forward memory (Leiter-R, Roid & Miller, 1997) and the Corsi block-tapping tasks (Corsi 1972) were used to assess spatial working memory. In both tasks, the examiner tapped a growing number of elements — familiar pictures in the forward memory task and wooden cubes in the Corsi task — in a particular sequence and asked the children to reproduce the sequence. For the Corsi task, we used the BVN 5-11 version (Bisiacchi, Cendron, Gugliotta, Tressoldi, & Vio, 2005). Cronbach's alpha was calculated for the forward memory task (.81; Roid & Miller, 1997). The test-retest reliability was .60 for the Corsi task (Mammarella, Toso, Pazzaglia, & Cornoldi, 2008).

Statistical Analysis

Multivariate analysis of variance (MANOVA) and univariate tests were used to explore the differences in the task performance between children with ASD and TD children. The *partial eta squared* value was considered when analysing the comparisons. The partial eta squared (effect size), namely, the proportion of variance accounting for the effect, was obtained by dividing the between-group deviation by the total deviation ($\eta^2_p = SSB/SST$). Values lower than .06 indicate a low effect size, values between .06 and .13 reveal a moderate effect size, and values larger than .14 correspond to a large effect size (Cohen, 1988).

To analyse the pattern of strengths and weaknesses in both groups, we used a deviation score following the Kuschner, Bennetto, and Yost (2007) approach. After calculating a mean subtest score for each child from the memory subtests (except Corsi), deviation scores were calculated by subtracting the child's overall mean from each subtest score (Kuschner et al., 2007). These scores represented the degree to which a subtest result was higher or lower than the participants' average score. Cohen's *d* with the Borenstein (2009) formula was used to compute the effect size of significant pairwise comparisons. Following Cohen (1988), the *d* values may be interpreted according to these intervals: .2 to .4 indicate a small effect; .5 to .7 indicate an intermediate effect; .8 and higher indicate a strong effect.

Results

The descriptive analysis showed that, on average, both groups performed in the normal range for all the considered measures, except the face memory task, in which the group with HFA presented a clinical score (Table 2). The MANOVA indicated a statistically significant difference between the two groups, $F(7, 20) = 3{,}293$, $p = .017$; Wilk's $\Lambda = 0.465$, partial $\eta^2 = .535$. The results from the univariate tests (Table 2) showed that the children with ASD did not differ form the TD group in the associative memory tasks and in the recognition memory for shapes. On the other hand, significant differences between the TD group and the group with ASD with a high effect size were found in the face memory ($F(1,27) = 12.141$, $p = .002$, $\eta^2_p = 0.318$) and forward memory tasks ($F(1,27) = 5.658$, $p = .025$, $\eta^2_p = 0.179$).

The paired t-tests between the deviation scores analysed the memory profile of each group in depth. As we can observe from the mean deviation scores (Table 3) and the results of our analysis (Table 4), the two groups showed better performance in associative memory than recognition memory (all ps $< .05$, Table 4), both in the immediate and delayed conditions. Moreover, children with HFA presented more discrepancies than TD children, showing better performance in the associative memory tasks than in the forward memory and facial memory tasks (all ps $< .005$, Table 4).

Discussion

The first aim of this study was to investigate visual memory in children with HFA using tasks and procedures that minimize verbal language. Based on the literature, children with ASD show a less impaired profile than adults (Chien et al., 2015; O'Hearn et al., 2014), especially if they have a an average IQ. However, we expected an uneven visual memory profile in children with ASD with deficits in recognition memory for faces, which has been found to be impaired in adolescents (Snow et al., 2011), and in spatial working memory (Wang et al., 2017). Therefore, children with HFA in our sample showed profound difficulties with face memory, and they appeared to be impaired in the VSWM task with semantic stimuli, while performance in the other visual memory tasks appeared to be preserved.

The deviation score analysis showed that children with HFA presented a memory profile characterized by higher variability among tasks and confirmed that face memory is the weakest aspect of HFA memory functioning. On the other hand, the HFA memory profile is characterized by some strengths. In terms of associative memory, both in the immediate and delayed tasks, children with HFA had the best performance. In contrast, TD children presented a more homogeneous memory profile, with relatively weak performance in recognition memory tasks.

In accordance with the findings of previous research on both children and adults, associative memory appeared to be a well-preserved area (Ambery, Russell, Perry, Morris and Murphy, 2006; Boucher & Warrington, 1976; Williams et al., 2005a). Since our associative memory tasks are structured as a cued recall, our results also confirm unimpaired performance in these types of tasks. Various studies highlight that individuals with HFA have intact cued recall performance in tasks that use word lists (Gardiner, Bowler, & Grice, 2003; Mottron et al., 2001; Phelan, Filliter, & Johnson, 2011), sounds and symbols, or object and location associations (Williams et al., 2006).

In accordance with previous studies that suggest preserved or superior performance in recognition memory, children with HFA and TD children did not differ in this area. In a study by Salmond et al. (2005) using the Rivermead Behavioural Memory Test and the Children's Memory Scale, children with HFA showed similar performance in recognizing auditory stimuli to TD children. Bigham et al. (2010) explored recognition memory for meaningless shapes. Children were shown 16 pictures, one at a time, and were asked to remember them. Children were then asked to recognize the previously seen pictures that were now presented with three distracters. The group with HFA was as capable as the TD children at recognizing these pictures. This result was confirmed by Salmanian et al. (2012) using CANTAB. The present study adds to the literature by demonstrating that ASD and TD groups showed a similar memory profile, with relatively weaker performance in recognition memory compared to associative memory, both in the immediate and delayed conditions.

In contrast, face memory emerged as a specific area of impairment for children with HFA, as reported by previous studies on children and adults. Williams et al. (2005a), for example, used face memory from the Wechsler Memory Scale-III to evaluate this type of memory. The results showed that children with HFA remembered significantly fewer faces than TD children that were matched for mental age (see also Hauck, Fein, Maltby, Waterhouse, & Feinstein, 1998). Snow et al. (2011) also confirmed this pattern in adolescents with HFA. In particular, they demonstrate that individuals with HFA were more able to remember inanimate stimuli presented with the same visual characteristics (e.g., brightness and grey scale) than human faces and that they remembered fewer faces than TD participants. On the basis of eye movements towards faces during the encoding phase of the experiment, the authors attributed this recognition memory impairment to abnormal attention/encoding rather than to memorization processes. In contrast, Dwyer et al. (2018), using electrophysiological measures, confirmed that face processing involves two distinct processes, i.e., face perception and face memorization; however, these authors found that face recognition impairments in individuals with ASD were more pronounced than face perception problems. In our sample, recognition memory is confirmed as the more impaired area of the memory profile in children with HFA, but it remains unclear which aspect of face processing —face perception or face memory — is more impaired.

Regarding VSWM, our results highlight different aspects. In both tasks, children were asked to memorize and point to a growing number of elements, familiar pictures in the forward memory task and wooden cubes in the Corsi task. In the Corsi task, children with HFA and TD children performed in a similar way, while in the forward memory task, performance was impaired in children with HFA. The two tasks used in this study might be considered homogeneous for the type of request; however, in the forward memory, children may be supported by the semantic mediation of the meaningful shapes, as suggested by Mammarella et al. (2014), who in manipulating the semantic properties of the visuospatial material did not find that children with ASD had an advantage in recalling stimuli in the high semantic condition. Another possible explanation relies on the hypothesis that this task may involve more active WM processes in individuals with ASD than in TD individuals (e.g., Hamilton et al., 2018). The effect of task complexity was documented by Morris et al. (1999), who found a deficit in VSWM in a high memory load condition in individuals with ASD compared to that in an IQ-matched control group. These results were confirmed by Landa & Goldberg (2005) in a study involving children with HFA and by Steele, Minshew, Luna, & Sweeney (2007) who, by employing the Cambridge Neuropsychological Test Automated Battery (CANTAB) to assess memory, found that children with HFA made more errors than TD controls and that the memory performance of children with HFA was greatly influenced by memory load compared to that of TD children. As mentioned in the introduction, the results of VSWM functioning in individuals with ASD are inconsistent, but as suggested by Macizo et al. (2016), using simple tasks and controlling for IQ helps eliminate the differences found between children with ASD and TD children. The impossibility of activating semantic coding in the presence of complex stimuli might be responsible for the impairment observed in children with ASD in the forward memory task compared to that in the Corsi task.

Summarizing the findings of the present study, the memory profile of children with ASD showed impaired performance in face memory and in forward memory with semantic stimuli and showed relative strength in associative memory. Both the impairments and relative strengths found in the present sample of children with ASD are compatible with WCC theory (Frith, 1989, 2012) and the LUT learning style (Quian & Lipkin, 2011). The WCC theory of ASD does not discriminate between different types of stimuli (i.e., human vs. non-human) but points to the different processing levels of the stimuli. Thus, deficits in memory for faces might be due to weaknesses in areas responsible for integrative and holistic processing (Dwyer et al., 2018), as well as difficulties in forward memory tasks, in which impaired access to the meaning of the stimuli did not advantage children with ASD as it did TD children. Additionally, the relative strength found in associative memory performance and the unimpaired performance in recognition memory and the VSWM Corsi task are in accordance with WCC theory and the LUT learning style, which hypothesize a detail-focused processing style in children with ASD (but Souza, Coco, Pinho, Filipe, & Carmo, 2016). Since the LUT learning style does not allow generalization, it corresponds well with tasks that contain little inherent regularity for generalization, such as associative tasks (i.e., name–number associations in a phonebook). In contrast, faces are complex, dynamic stimuli that may overload the inefficient LUT system and make it difficult to extract social information from facial cues.

Some limitations of this study must be mentioned. First, the sample is relatively small and the results cannot be generalized to the entire population also because of the huge variability often present in the cognitive profile of individuals with ASD. Moreover, involving an LFA group with an IQ-matched group could improve our comprehension of the visual memory profile across the spectrum. Another limitation arises from the tasks employed to evaluate VSWM. Using tasks of different complexity might have allowed us to better test the existence of differences in functioning between ASD and TD populations. Despite these limitations, this study adds to the knowledge of visual memory in children with ASD, contributing to a literature that has mostly focused on adulthood.

Conclusion

In summary, our results support the hypothesis that the level of stimulus processing may influence memory performance by having a large impact on tasks and stimuli that require access to a semantic or global level of processing. This cognitive style has consequences for different aspects of individual functioning. For example, various studies have highlighted the influence of memory on social abilities (Bradshaw, Shick & Chawarska, 2011; Corbett, Newsom, Key, Qualls, & Edmiston, 2014; Ewing, Pelicano, & Rhodes, 2013; Weigelt, Koldewyn, & Kanwisher, 2012). For example, research by Corbett et al. (2014) demonstrated that face memory both in TD children and children with HFA was strongly related to social engagement patterns. Lower performance in facial memory tasks was related to less social interaction and more self-play; in contrast, higher performance was associated with more cooperative play. Moreover, our results confirm the absence of differences in associative and recognition memory between TD children and children with ASD. This result has implications for intervention, suggesting that acquiring new abilities may benefit from explicitly associating new stimuli with well-known stimuli.

In addition, the two groups do not differ in VSWM for non-semantic stimuli. Nevertheless, only children with ASD present specific failures in VSWM in their memory profiles and show no deficits in associative or recognition performance.

Taken together, these results confirm that individuals with ASD may differ from the TD population in terms of learning strategies. The use of an LUT strategy in the learning process is more demanding, and as a consequence, performance may be affected. This means that teachers and educators should control for the cognitive load required by the tasks comprised in an intervention programme when new behaviours are implemented. More recently, it has been shown that individuals with ASD may adopt an interpolation strategy when they are explicitly taught to do so (Sapey-Triomphe et al., 2018). Therefore, in teaching children with ASD, it is important to take the more demanding memorization strategy employed by them into account and to support the use of a more efficient strategy.

Compliance with Ethical Standards

The authors of this manuscript declare that they have no conflicts of interest.

Ethical approval: All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and national research committee (Ethical Code of Italian Psychology Order and the Ethical guidelines of the Italian Association of Psychology) and with the 2013 Helsinki Declaration.

Informed consent: Informed consent was obtained from the parents of all children participants included in the study.

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Tables

Table 1. Age and IQ comparisons.

	HFA (13:2)		TD (12:3)		T-Test		Effect size
	M	SD	M	SD	t	p	d
Chronological Age (Months)	114.47	16.49	110.20	16.45	.710	.484	-0.259
Brief IQ	92.33	12.03	97.67	10.74	-1.281	.211	0.468

Table 2. Descriptive and MANOVA results. Excepting for Corsi raw scores, the performance is expressed in scaled scores. Greater the scores, better is the performance.

	HFA (13:2)		TD (12:3)		MANOVA (df = 1, 27)		
	M	SD	M	SD	F	p	η^2_p
Associated Pairs	11.53	2.50	11.13	2.64	0.032	.860	.001
Delayed Pairs	11.07	2.89	11.33	2.61	0.146	.705	.006
Immediate Recognition	7.15	2.85	8.87	2.00	3.462	.074	.118
Delayed Recognition	7.15	2.93	8.93	2.40	3.106	.090	.107
Facial Memory	6.13	3.68	10.13	2.83	12.141	.002	.318
Forward Memory	8.13	2.88	10.13	2.20	5.658	.025	.179
Corsi	3.87	1.24	4.07	0.70	2.048	.164	.073

Table 3. Descriptive results of the deviation scores.

	HFA		TD	
DS	M	SD	M	SD
AP	2.84	1.42	1.04	2.00
DP	2.37	2.14	1.24	1.88
IR	-1.21	2.19	-1.22	1.48
DR	-1.21	1.96	-1.16	1.84
MFace	-2.56	3.54	0.04	2.55
FM	-0.56	1.67	0.04	2.15

DS=Deviation Scores; AP=Associated Pairs; IR=Immediate Recognition; FM=Forward Memory; DP=Delayed Pairs; DR=Delayed Recognition; MFace=Facial Memory

Table 4. T-test and effect sizes (d) of the deviation scores comparisons.

	HFA				TD			
	t	df	p	d	t	df	p	d
AP - DP	1.073	14	.301	0.277	-0.587	14	.567	-0.076
AP - IR	4.866	12	**.000**	1.350	2.871	14	**.012**	0.965
AP - DR	4.591	12	**.001**	1.273	2.566	14	**.022**	0.871
AP - MFace	4.953	14	**.000**	1.279	1.040	14	.316	0.365
AP - FM	7.830	14	**.000**	2.022	1.099	14	.290	0.412
DP - IR	3.742	12	**.003**	1.038	3.138	14	**.007**	1.059
DP - DR	3.629	12	**.003**	1.006	2.770	14	**.015**	0.956
DP - MFace	3.906	14	**.002**	1.009	1.302	14	.214	0.441
DP - FM	4.911	14	**.000**	1.268	1.427	14	.175	0.497
IR - DR	0.000	12	1.000	0	-0.202	14	.843	-0.029
IR - MFace	0.971	12	.351	0.269	-1.604	14	.131	-0.514
IR - FM	-0.829	12	.423	-0.230	-1.743	14	.103	-0.603
DR - MFace	1.118	12	.285	0.310	-1.267	14	.226	-0.458
DR-FM	-0.888	12	.392	-0.246	1.718	14	.108	0.520
MFace - FM	-1.615	14	.129	-0.417	0.000	14	1.000	0

Note: AP=Associated Pairs; IR=Immediate Recognition; FM=Forward Memory; DP=Delayed Pairs; DR=Delayed Recognition; MFace=Facial Memory